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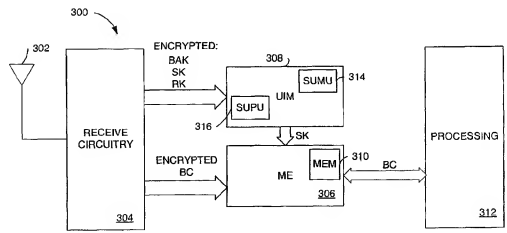
(54) Title: METHOD AND APPARATUS FOR SECURITY IN A DATA PROCESSING SYSTEM



(57) Abstract: Method and apparatus for secure transmissions. Each user is provided a registration key. A long-time updated broadcast key is encrypted using the registration key and provided periodically to a user. A short-time updated key is encrypted using the broadcast key and provided periodically to a user. Broadcasts are then encrypted using the short-time key, wherein the user decrypts the broadcast message using the short-time key.

WO 02/080449 A1

METHOD AND APPARATUS FOR SECURITY IN A DATA PROCESSING SYSTEM

BACKGROUND

Claim of Priority under 35 U.S.C. §120

[1001] The present Application for Patent claims priority of U.S. Provisional Application No. 60/279,970, filed March 28,2001, assigned to the assignee hereof and hereby expressly incorporated by reference herein.

Reference to Co-Pending Applications for Patent

[1002] The present invention is related to the following Applications for Patent in the U.S. Patent & Trademark Office:

"METHOD AND APPARATUS FOR OVERHEAD MESSAGING IN A WIRELESS COMMUNICATION SYSTEM" by Nikolai Leung, having Attorney Docket No. 010439, filed concurrently herewith and assigned to the assignee hereof, and which is expressly incorporated by reference herein;

"METHOD AND APPARATUS FOR OUT-OF-BAND TRANSMISSION OF BROADCAST SERVICE OPTION IN A WIRELESS COMMUNICATION SYSTEM" by Nikolai Leung, having Attorney Docket No. 010437, filed concurrently herewith and assigned to the assignee hereof, and which is expressly incorporated by reference herein;

"METHOD AND APPARATUS FOR BROADCAST SIGNALING IN A WIRELESS COMMUNICATION SYSTEM" by Nikolai Leung, having Attorney Docket No. 010438, filed concurrently herewith and assigned to the assignee hereof, and which is expressly incorporated by reference herein;

"METHOD AND APPARATUS FOR TRANSMISSION FRAMING IN A WIRELESS COMMUNICATION SYSTEM" by Raymond Hsu, having Attorney Docket No. 010498, filed concurrently herewith and assigned to the assignee hereof, and which is expressly incorporated by reference herein;

"METHOD AND APPARATUS FOR DATA TRANSPORT IN A WIRELESS COMMUNICATION SYSTEM" by Raymond Hsu, having Attorney Docket No. 010499, filed concurrently herewith and assigned to the assignee hereof, and which is expressly incorporated by reference herein; and

"METHOD AND APPARATUS FOR HEADER COMPRESSION IN A WIRELESS COMMUNICATION SYSTEM" by Raymond Hsu, having Attorney Docket No. 010500, filed concurrently herewith and assigned to the assignee hereof, and which is expressly incorporated by reference herein.

Field

[1003] The present invention relates to data processing systems generally and specifically, to methods and apparatus for security in a data processing system.

Background

[1004] Security in data processing and information systems, including communications systems, contributes to accountability, fairness, accuracy, confidentiality, operability, as well as a plethora of other desired criteria. Encryption, or the general field of cryptography, is used in electronic commerce, wireless communications, broadcasting, and has an unlimited range of applications. In electronic commerce, encryption is used to prevent fraud in and verify financial transactions. In data processing systems, encryption is used to verify a participant's identity. Encryption is also used to prevent hacking, protect Web pages, and prevent access to confidential documents.

[1005] Asymmetric encryption system, often referred to as a cryptosystem, uses a same key (i.e., the secret key) to encrypt and decrypt a message. Whereas an asymmetric encryption system uses a first key (i.e., the public key) to encrypt a message and uses a different key (i.e., the private key) to decrypt it. Asymmetric cryptosystems are also called public key cryptosystems. A problem exists in symmetric cryptosystems in the secure provision of the secret key from a sender to a recipient. Further, a problem exists when keys or other encryption mechanisms are updated frequently. In a data processing system

methods of securely updating keys incur processing time, memory storage and other processing overhead. In a wireless communication system, updating keys uses valuable bandwidth used for transmission.

[1006] The prior art does not provide a method for updating keys to a large group of mobile stations in order that they may access an encrypted broadcast. There is a need, therefore, for a secure and efficient method of updating keys in a data processing system. Further, there is a need for a secure and efficient method of updating keys in a wireless communication system.

SUMMARY

[1007] Embodiments disclosed herein address the above stated needs by providing a method for security in a data processing system.

[1008] In one aspect a method for secure transmissions includes determining a registration key specific to a participant in a transmission, determining a first key, encrypting the first key with the registration key, determining a second key, encrypting the second key with the first key and updating the first and second keys.

[1009] In another aspect, a method for secure reception of a transmission includes receiving a registration key specific to a participant in a transmission, receiving a first key, decrypting the first key with the registration key, receiving a second key, decrypting the second key with the first key, receiving a broadcast stream of information, and decrypting the broadcast stream of information using the second key.

[1010] In still another aspect a wireless communication system supporting a broadcast service option has an infrastructure element including a receive circuitry, a user identification unit, operative to recover a short-time key for decrypting a broadcast message, and a mobile equipment unit adapted to apply the short-time key for decrypting the broadcast message. The user identification unit includes a processing unit operative to decrypt key information, and a memory storage unit for storing a registration key.

BRIEF DESCRIPTION OF THE DRAWINGS

[1011] FIG. 1A is a diagram of a cryptosystem.

[1012] FIG. 1B is a diagram of a symmetric cryptosystem.

[1013] FIG. 1C is a diagram of an asymmetric cryptosystem.

[1014] FIG. 1D is a diagram of a PGP encryption system.

[1015] FIG. 1E is a diagram of a PGP decryption system.

[1016] FIG. 2 is a diagram of a spread spectrum communication system that supports a number of users.

[1017] FIG. 3 is a block diagram of the communication system supporting broadcast transmissions.

[1018] FIG. 4 is a block diagram of a mobile station in a wireless communication system.

[1019] FIG. 5 is a model describing the updating of keys within a mobile station used for controlling broadcast access.

[1020] FIG. 6 is a model describing cryptographic operations within a UIM.

[1021] FIGs. 7A-7D illustrate a method of implementing security encryption in a wireless communication system supporting broadcast transmissions.

[1022] FIG. 7E is a timing diagram of key update periods of a security option in a wireless communication system supporting broadcast transmissions.

[1023] FIGs. 8A-8D illustrate application of a security encryption method in a wireless communication system supporting broadcast transmissions.

DETAILED DESCRIPTION

[1024] The word "exemplary" is used exclusively herein to mean "serving as an example, instance, or illustration." Any embodiment described herein as "exemplary" is not necessarily to be construed as preferred or advantageous over other embodiments.

[1025] Wireless communication systems are widely deployed to provide various types of communication such as voice, data, and so on. These systems may be based on code division multiple access (CDMA), time division multiple access (TDMA), or some other modulation techniques. A CDMA system

provides certain advantages over other types of system, including increased system capacity.

[1026] A system may be designed to support one or more standards such as the "TIA/EIA/IS-95-B Mobile Station-Base Station Compatibility Standard for Dual-Mode Wideband Spread Spectrum Cellular System" referred to herein as the IS-95 standard, the standard offered by a consortium named "3rd Generation Partnership Project" referred to herein as 3GPP, and embodied in a set of documents including Document Nos. 3G TS 25.211, 3G TS 25.212, 3G TS 25.213, and 3G TS 25.214, 3G TS 25.302, referred to herein as the W-CDMA standard, the standard offered by a consortium named "3rd Generation Partnership Project 2" referred to herein as 3GPP2, and TR-45.5 referred to herein as the cdma2000 standard, formerly called IS-2000 MC. The standards cited hereinabove are hereby expressly incorporated herein by reference.

[1027] Each standard specifically defines the processing of data for transmission from base station to mobile, and vice versa. As an exemplary embodiment the following discussion considers a spread-spectrum communication system consistent with cdma2000 systems. Alternate embodiments may incorporate another standard/system. Still other embodiments may apply the security methods disclosed herein to any type of data processing system using a cryptosystem.

[1028] A cryptosystem is a method of disguising messages thus allowing a specific group of users to extract the message. FIG. 1A illustrates a basic cryptosystem 10. Cryptography is the art of creating and using cryptosystems. Cryptanalysis is the art of breaking cryptosystems, i.e., receiving and understanding the message when you are not within the specific group of users allowed access to the message. The original message is referred to as a plaintext message or plaintext. The encrypted message is called a ciphertext, wherein encryption includes any means to convert plaintext into ciphertext. Decryption includes any means to convert ciphertext into plaintext, i.e., recover the original message. As illustrated in FIG. 1A, the plaintext message is encrypted to form a ciphertext. The ciphertext is then received and decrypted to recover the plaintext. While the terms plaintext and ciphertext generally refer to data, the concepts of encryption may be applied to any digital information, including audio and video data presented in digital form. While the description

of the invention provided herein uses the term plaintext and ciphertext consistent with the art of cryptography, these terms do not exclude other forms of digital communications.

[1029] A cryptosystem is based on secrets. A group of entities shares a secret if an entity outside this group cannot obtain the secret without significantly large amount of resources. This secret is said to serve as a security association between the groups of entities.

[1030] A cryptosystem may be a collection of algorithms, wherein each algorithm is labeled and the labels are called keys. A symmetric encryption system, often referred to as a cryptosystem, uses a same key (i.e., the secret key) to encrypt and decrypt a message. A symmetric encryption system 20 is illustrated in FIG. 1B, wherein both the encryption and decryption utilize a same private key.

[1031] In contrast, an asymmetric encryption system uses a first key (i.e., the public key) to encrypt a message and uses a different key (i.e., the private key) to decrypt it. FIG. 1C illustrates an asymmetric encryption system 30 wherein one key is provided for encryption and a second key for decryption. Asymmetric cryptosystems are also called public key cryptosystems. The public key is published and available for encrypting any message, however, only the private key may be used to decrypt the message encrypted with the public key.

[1032] A problem exists in symmetric cryptosystems in the secure provision of the secret key from a sender to a recipient. In one solution a courier may be used to provide the information, or, a more efficient and reliable solution may be to use a public key cryptosystem, such as a public-key cryptosystem defined by Rivest, Shamir, and Adleman (RSA) which is discussed hereinbelow. The RSA system is used in the popular security tool referred to as Pretty Good Privacy (PGP), which is further detailed hereinbelow. For instance, an originally recorded cryptosystem altered letters in a plaintext by shifting each letter by n in the alphabet, wherein n is a predetermined constant integer value. In such a scheme, an "A" is replaced with a "D," etc., wherein a given encryption scheme may incorporate several different values of n. In this encryption scheme "n" is the key. Intended recipients are provided the encryption scheme prior to receipt of a ciphertext. In this way, only those knowing the key should be able to decrypt the ciphertext to recover the plaintext. However, by calculating the key

with knowledge of encryption, unintended parties may be able to intercept and decrypt the ciphertext, creating a security problem.

[1033] More complicated and sophisticated cryptosystems employ strategic keys that are deter interception and decryption from unintended parties. A classic cryptosystem employs encryption functions E and decryption functions D such that:

$$D\_K(E\_K(P)) = P, \text{ for any plaintext } P. \quad (1)$$

[1034] In a public-key cryptosystem, E_K is easily computed from a known ``public key" Y which in turn is computed from K. Y is published, so that anyone can encrypt messages. The decryption function D_K is computed from public key Y, but only with knowledge of a private key K. Without the private key K an unintended recipient may not decrypt the ciphertext so generated. In this way only the recipient who generated K can decrypt messages.

[1035] RSA is a public-key cryptosystem defined by Rivest, Shamir, and Adleman. As an example, consider plaintexts as positive integers up to 2^{512}. Keys are quadruples (p,q,e,d), with p given as a 256-bit prime number, q as a 258-bit prime number, and d and e large numbers with $(de - 1)$ divisible by $(p-1)(q-1)$. Further, define the encryption function as:

$$E\_K(P) = P^e \bmod pq,\ D\_K(C) = C^d \bmod pq. \quad (2)$$

[1036] While, E_K is easily computed from the pair (pq,e), there is no known simple way to compute D_K from the pair (pq,e). Therefore, the recipient that generates K can publish (pq,e). It is possible to send a secret message to the recipient, as he is the one able to read the message.

[1037] PGP combines features from symmetric and asymmetric encryption. FIGs. 1D and 1E illustrate a PGP cryptosystem 50, wherein a plaintext message is encrypted and recovered. In FIG. 1D, the plaintext message is compressed to save modem transmission time and disk space. Compression strengthens cryptographic security by adding another level of translation to the encrypting and decrypting processing. Most cryptanalysis techniques exploit patterns found in the plaintext to crack the cipher. Compression reduces these patterns in the plaintext, thereby enhancing resistance to cryptanalysis. Note that one embodiment does not compress plaintext or other messages that are too short to compress or which don't compress well aren't compressed.

[1038] PGP then creates a *session key,* which is a one-time-only secret key. This key is a random number that may be generated from any random event(s), such as random movements of mouse and the keystrokes while typing. The session key works with a secure encryption algorithm to encrypt the plaintext, resulting in ciphertext. Once the data is encrypted, the session key is then encrypted to the recipient's public key. This public key-encrypted session key is transmitted along with the ciphertext to the recipient.

[1039] For decryption, as illustrated in FIG. 1E, the recipient's copy of PGP uses a private key to recover the temporary session key, which PGP then uses to decrypt the conventionally encrypted ciphertext. The combination of encryption methods takes advantage of the convenience of public key encryption and the speed of symmetric encryption. Symmetric encryption is generally much faster than public key encryption. Public key encryption in turn provides a solution to key distribution and data transmission issues. In combination, performance and key distribution are improved without any sacrifice in security.

[1040] A key is a value that works with a cryptographic algorithm to produce a specific ciphertext. Keys are basically very large numbers. Key size is measured in bits. In public key cryptography, security increases with key size, however, public key size and the symmetric encryption private key size are not generally related. While the public and private keys are mathematically related, a difficulty arises in deriving a private key given only a public key. Deriving the private key is possible given enough time and computing power, making the selection of key size an important security issue. The goal is to have a large key that is secure, while maintaining key size sufficiently small for quick processing. An additional consideration is the expected interceptor, specifically, what is the importance of a message to a third party, and how much resource does a third party have to decrypt.

[1041] Larger keys will be cryptographically secure for a longer period of time. Keys are stored in encrypted form. PGP specifically stores keys in two files; one for public keys and one for private keys. These files are called *keyrings.* In application, a PGP encryption system adds the public keys of target recipients to the sender's public keyring. The sender's private keys are stored on the sender's private keyring.

[1042] As discussed in the examples given hereinabove, the method of distributing the keys used for encryption and decryption can be complicated. The ``key exchange problem'' involves first ensuring that keys are exchanged such that both the sender and receiver can perform encryption and decryption, respectively, and for bi-directional communication, such that the sender and receiver can both encrypt and decrypt messages. Further, it is desired that key exchange be performed so as to preclude interception by a third unintended party. Finally, an additional consideration is authentication providing assurance to the receiver that a message was encrypted by an intended sender and not a third party. In a private key exchange system, the keys are exchanged secretly providing improved security upon successful key exchange and valid authentication. Note that the private key encryption scheme implicitly provides authentication. The underlying assumption in a private key cryptosystem is that only the intended sender will have the key capable of encrypting messages delivered to the intended receiver. While public-key cryptographic methods solve a critical aspect of the `key-exchange problem', specifically their resistance to analysis even with the presence a passive eavesdropper during exchange of keys, they do not solve all problems associated with key exchange. In particular, since the keys are considered `public knowledge,' (particularly with RSA) some other mechanism is desired to provide authentication, as possession of keys alone (sufficient to encrypt messages) is no evidence of a particular unique identity of the sender, nor is possession of a corresponding decryption key by itself enough to establish the identity of the recipient.

[1043] One solution is to develop a key distribution mechanism that assures that listed keys are actually those of the given entities, sometimes called a trusted authority, certificate authority, or third part escrow agent. The authority typically does not actually generate keys, but does ensure that the lists of keys and associated identities kept and advertised for reference by senders and receivers are correct and uncompromised. Another method relies on users to distribute and track each other's keys and trust in an informal, distributed fashion. Under RSA, if a user wishes to send evidence of their identity in addition to an encrypted message, a signature is encrypted with the private key. The receiver can use the RSA algorithm in reverse to verify that the information decrypts, such that only the sender could have encrypted the plaintext by use of

the secret key. Typically the encrypted `signature' is a `message digest' that comprises a unique mathematical `summary' of the secret message (if the signature were static across multiple messages, once known previous receivers could use it falsely). In this way, theoretically only the sender of the message could generate a valid signature for that message, thereby authenticating it for the receiver.

[1044] A message digest is often computed using a cryptographic hash function. A cryptographic hash function computes a value (with a fixed number of bits) from any input, regardless of the length of the input. One property of a cryptographic hash function is this: given an output value, it is computationally difficult to determine an input that will result in that output. An example of a cryptographic hash function is SHA-1 as described in "Secure Hash Standard," FIPS PUB 180-1, promulgated by the Federal Information Processing Standards Publications (FIPS PUBS) and issued by the National Institute of Standards and Technology.

[1045] FIG. 2 serves as an example of a communications system 100 that supports a number of users and is capable of implementing at least some aspects and embodiments of the invention. Any of a variety of algorithms and methods may be used to schedule transmissions in system 100. System 100 provides communication for a number of cells 102A through 102G, each of which is serviced by a corresponding base station 104A through 104G, respectively. In the exemplary embodiment, some of base stations 104 have multiple receive antennas and others have only one receive antenna. Similarly, some of base stations 104 have multiple transmit antennas, and others have single transmit antennas. There are no restrictions on the combinations of transmit antennas and receive antennas. Therefore, it is possible for a base station 104 to have multiple transmit antennas and a single receive antenna, or to have multiple receive antennas and a single transmit antenna, or to have both single or multiple transmit and receive antennas.

[1046] Terminals 106 in the coverage area may be fixed (i.e., stationary) or mobile. As shown in FIG. 2, various terminals 106 are dispersed throughout the system. Each terminal 106 communicates with at least one and possibly more base stations 104 on the downlink and uplink at any given moment depending on, for example, whether soft handoff is employed or whether the

terminal is designed and operated to (concurrently or sequentially) receive multiple transmissions from multiple base stations. Soft handoff in CDMA communications systems is well known in the art and is described in detail in U.S. Patent No. 5,101,501, entitled "METHOD AND SYSTEM FOR PROVIDING A SOFT HANDOFF IN A CDMA CELLULAR TELEPHONE SYSTEM," which is assigned to the assignee of the present invention.

[1047] The downlink refers to transmission from the base station to the terminal, and the uplink refers to transmission from the terminal to the base station. In the exemplary embodiment, some of terminals 106 have multiple receive antennas and others have only one receive antenna. In FIG. 2, base station 104A transmits data to terminals 106A and 106J on the downlink, base station 104B transmits data to terminals 106B and 106J, base station 104C transmits data to terminal 106C, and so on.

[1048] Increasing demand for wireless data transmission and the expansion of services available via wireless communication technology have led to the development of specific data services. One such service is referred to as High Data Rate (HDR). An exemplary HDR service is proposed in "EIA/TIA-IS856 cdma2000 High Rate Packet Data Air Interface Specification" referred to as "the HDR specification." HDR service is generally an overlay to a voice communication system that provides an efficient method of transmitting packets of data in a wireless communication system. As the amount of data transmitted and the number of transmissions increases, the limited bandwidth available for radio transmissions becomes a critical resource. There is a need, therefore, for an efficient and fair method of scheduling transmissions in a communication system that optimizes use of available bandwidth. In the exemplary embodiment, system 100 illustrated in FIG. 2 is consistent with a CDMA type system having HDR service.

[1049] According to one embodiment, the system 100 supports a high-speed multimedia broadcasting service referred to as High-Speed Broadcast Service (HSBS). An example application for HSBS is video streaming of movies, sports events, etc. The HSBS service is a packet data service based on the Internet Protocol (IP). According to the exemplary embodiment, a service provider indicates the availability of such high-speed broadcast service to the users. The users desiring the HSBS service subscribe to receive the service and may

discover the broadcast service schedule through advertisements, Short Management System (SMS), Wireless Application Protocol (WAP), etc. Mobile users are referred to as Mobile Stations (MSs). Base Stations (BSs) transmit HSBS related parameters in overhead messages. When an MS desires to receive the broadcast session, the MS reads the overhead messages and learns the appropriate configurations. The MS then tunes to the frequency containing the HSBS channel, and receives the broadcast service content.

[1050] The service being considered is a high-speed multimedia broadcasting service. This service is referred to as High-Speed Broadcast Service (HSBS) in this document. One such example is video streaming of movies, sports events, etc. This service will likely be a packet data service based on the Internet Protocol (IP).

[1051] The service provider will indicate the availability of such high-speed broadcast service to the users. The mobile station users who desire such service will subscribe to receive this service and may discover the broadcast service schedule through advertisements, SMS, WAP, etc. Base stations will transmit broadcast service related parameters in overhead messages. The mobiles that wish to listen to the broadcast session will read these messages to determine the appropriate configurations, tune to the frequency containing the high-speed broadcast channel, and start receiving the broadcast service content.

[1052] There are several possible subscription/revenue models for HSBS service, including free access, controlled access, and partially controlled access. For free access, no subscription is needed by the mobiles to receive the service. The BS broadcasts the content without encryption and interested mobiles can receive the content. The revenue for the service provider can be generated through advertisements that may also be transmitted in the broadcast channel. For example, upcoming movie-clips can be transmitted for which the studios will pay the service provider.

[1053] For controlled access, the MS users subscribe to the service and pay the corresponding fee to receive the broadcast service. Unsubscribed users are not able to receive the HSBS service. Controlled access can be achieved by encrypting the HSBS transmission/content so that only the subscribed users can decrypt the content. This may use over-the-air encryption key exchange

procedures. This scheme provides strong security and prevents theft-of-service.

[1054] A hybrid access scheme, referred to as partial controlled access, provides the HSBS service as a subscription-based service that is encrypted with intermittent unencrypted advertisement transmissions. These advertisements may be intended to encourage subscriptions to the encrypted HSBS service. Schedule of these unencrypted segments could be known to the MS through external means.

[1055] A wireless communication system 200 is illustrated in FIG. 3, wherein video and audio information is provided to Packetized Data Service Network (PDSN) 202 by a Content Server (CS) 201. The video and audio information may be from televised programming or a radio transmission. The information is provided as packetized data, such as in IP packets. The PDSN 202 processes the IP packets for distribution within an Access Network (AN). As illustrated the AN is defined as the portions of the system including a BS 204 in communication with multiple MS 206. The PDSN 202 is coupled to the BS 204. For HSBS service, the BS 204 receives the stream of information from the PDSN 202 and provides the information on a designated channel to subscribers within the system 200. To control the access, the content is encrypted by the CS 201 before being provided to the PDSN 202. The subscribed users are provided with the decryption key so that the IP packets can be decrypted.

[1056] FIG. 4 details an MS 300, similar to MS 206 of FIG. 3. The MS 300 has an antenna 302 coupled to receive circuitry 304. The MS 300 receives transmissions from a BS (not shown) similar to BS 204 of FIG. 3. The MS 300 includes a User Identification Module (UIM) 308 and a Mobile Equipment (ME) 306. The receive circuitry is coupled to the UIM 308 and the ME 306. The UIM 308 applies verification procedures for security of the HSBS transmission and provides various keys to the ME 306. The ME 306 may be coupled to processing unit 312. The ME 306 performs substantial processing, including, but not limited to, decryption of HSBS content streams. The ME 306 includes a memory storage unit, MEM 310. In the exemplary embodiment the data in the ME 306 processing (not shown) and the data in the ME memory storage unit, MEM 310 may be accessed easily by a non-subscriber by the use of limited resources, and therefore, the ME 306 is said to be insecure. Any information

passed to the ME 306 or processed by the ME 306 remains securely secret for only a short amount of time. It is therefore desired that any secret information, such as key(s), shared with the ME 306 be changed often.

[1057] The UIM 308 is trusted to store and process secret information (such as encryption keys) that should remain secret for a long time. As the UIM 308 is a secure unit, the secrets stored therein do not necessarily require the system to change the secret information often. The UIM 308 includes a processing unit referred to as a Secure UIM Processing Unit (SUPU) 316 and memory storage unit referred to as a Secure UIM Memory Unit (SUMU) 314 that is trusted to be secure. Within the UIM 308, SUMU 314 stores secret information in such a way that as to discourage unauthorized access to the information. If the secret information is obtained from the UIM 308, the access will require a significantly large amount of resources. Also within the UIM 308, the SUPU 316 performs computations on values that may be external to the UIM 308 and/or internal to the UIM 308. The results of the computation may be stored in the SUMU 314 or passed to the ME 306. The computations performed with the SUPU 316 can only be obtained from the UIM 308 by an entity with significantly large amount of resources. Similarly, outputs from the SUPU 316 that are designated to be stored within the SUMU 314 (but not output to the ME 306) are designed such that unauthorized interception requires significantly large amount of resources. In one embodiment, the UIM 308 is a stationary unit within the MS 300. Note that in addition to the secure memory and processing within the UIM 308, the UIM 308 may also include non-secure memory and processing (not shown) for storing information including telephone numbers, e-mail address information, web page or URL address information, and/or scheduling functions, etc.

[1058] Alternate embodiments may provide a removable and/or reprogrammable UIM. In the exemplary embodiment, the SUPU 316 does not have significant processing power for functions beyond security and key procedures, such as to allow encryption of the broadcast content of the HSBS. Alternate embodiments may implement a UIM having stronger processing power.

[1059] The UIM is associated with a particular user and is used primarily to verify that the MS 300 is entitled to the privileges afforded the user, such as access to the mobile phone network. Therefore, a user is associated with the

UIM 308 rather than an MS 300. The same user may be associated with multiple UIM 308.

[1060] The broadcast service faces a problem in determining how to distribute keys to subscribed users. To decrypt the broadcast content at a particular time, the ME must know the current decryption key. To avoid theft-of-service, the decryption key should be changed frequently, for example, every minute. These decryption keys are called Short-term Keys (SK). The SK is used to decrypt the broadcast content for a short-amount of time so the SK can be assumed to have some amount of intrinsic monetary value for a user. For example, this intrinsic monetary value may be a portion of the registration costs. Assume that the cost of a non-subscriber obtaining SK from the memory storage unit, MEM 310, of a subscriber exceeds the intrinsic monetary value of SK. That is, the cost of obtaining SK (illegitimately) exceeds the reward, so there is no benefit. Consequently, there is no need to protect SK in the memory storage unit, MEM 310. However, if a secret key has a lifetime longer than that of an SK, then the cost of obtaining this secret key (illegitimately) is less than the reward. In this situation, there is a benefit in obtaining such a key from the memory storage unit, MEM 310. Hence, ideally the memory storage unit, MEM 310 will not store secrets with a lifetime longer than that of an SK.

[1061] The channels used by the CS (not shown) to distribute the SK to the various subscriber units are considered insecure. Therefore, when distributing a given SK, the CS desires to use a technique that hides the value of the SK from non-subscribed users. Furthermore, the CS distributes the SK to each of a potentially large number of subscribers for processing in respective MEs within a relatively short timeframe. Known secure methods of key transmission are slow and require transmission of a large number of keys, and are generally not feasible for the desired criteria. The exemplary embodiment is a feasible method of distributing decryption keys to a large set of subscribers within a small time-frame in such a way that non-subscribers cannot obtain the decryption keys.

[1062] In the exemplary embodiment, the MS 300 supports HSBS in a wireless communication system. To obtain access to HSBS, the user must register and then subscribe to the service. Once the subscription is enabled, the various keys are updated periodically. In the registration process the CS

and UIM 308 agree on a Registration Key (RK) that serves as a security association between the user and the CS. The CS may then send the UIM further secret information encrypted with the RK. The RK is kept as a secret in the UIM 308, and is unique to a given UIM, i.e., each user is assigned a different RK. The registration process alone does not give the user access to HSBS. As stated hereinabove, after registration the user subscribes to the service. In the subscription process the CS sends the UIM 308 the value of a common Broadcast Access Key (BAK). The CS sends the MS 300, and specifically UIM 308, the value of BAK encrypted using the RK unique to UIM 308. The UIM 308 is able to recover the value of the original BAK from the encrypted version using the RK. The BAK serves as a security association between the CS and the group of subscribed users. The CS then broadcasts data called SK Information (SKI) that is combined with the BAK in the UIM 308 to derive SK. The UIM 308 then passes SK to the ME 306. In this way, the CS can efficiently distribute new values of SK to the ME of subscribed users.

[1063] The following paragraphs discuss the registration process in more detail. When a user registers with a given CS, the UIM 308 and the CS (not shown) set-up a security association. That is, the UIM 308 and the CS agree on a secret key RK. The RK is unique to each UIM 308, although if a user has multiple UIMs then these UIMs may share the same RK dependent on the policies of the CS. This registration may occur when the user subscribes to a broadcast channel offered by the CS or may occur prior to subscription. A single CS may offer multiple broadcast channels. The CS may choose to associate the user with the same RK for all channels or require the user to register for each channel and associate the same user with different RKs on different channels. Multiple CSs may choose to use the same registration keys or require the user to register and obtain a different RK for each CS.

[1064] Two common scenarios for setting up this security association include the Authenticated Key Agreement (AKA) method (as used in 3GPP) and the Internet Key Exchange (IKE) method as used in IPsec. In either case the UIM memory unit SUMU 314 contains a secret key referred to as the A-key. As an example, the AKA method is described. In the AKA method the A-key is a secret known only to the UIM and a trusted third party (TTP): the TTP may consist of more than one entity. The TTP is typically the mobile service provider

with whom the user is registered. All communication between the CS and TTP is secure, and the CS trusts that the TTP will not assist unauthorized access to the broadcast service. When the user registers, the CS informs the TTP that the user wishes to register for the service and provides verification of the user's request. The TTP uses a function (similar to a cryptographic hash function) to compute the RK from the A-key and additional data called Registration Key Information (RKI). The TTP passes RK, RKI to the CS over a secure channel along with other data not relevant to this submission. The CS sends RKI to the MS 300. The receiver circuitry 304 passes RKI to the UIM 308 and possibly passes RKI to the ME 306. The UIM 308 computes RK from RKI and the A-key that is stored in the UIM memory unit SUMU 314. The RK is stored in the UIM memory unit SUMU 314 and is not provided directly to the ME 306. Alternate embodiments may use an IKE scenario or some other method to establish the RK. The RK serves as the security association between the CS and UIM 308.

[1065] In the AKA method, the RK is a secret shared between the CS, UIM and TTP. Therefore, as used herein, the AKA method implies that any security association between the CS and UIM implicitly includes the TTP. The inclusion of the TTP in any security association is not considered a breach of security, as the CS trusts the TTP not to assist in unauthorized access to the broadcast channel. As stated hereinabove, if a key is shared with the ME 306, it is desirable to change that key often. This is due to the risk of a non-subscriber accessing information stored in memory storage unit, MEM 310 and thus allowing access to a controlled or partially controlled service. The ME 306 stores SK (key information used for decrypting broadcast content) in memory storage unit, MEM 310. The CS must send sufficient information for subscribed users to compute SK. If the ME 306 of a subscribed user could compute SK from this information, then additional information required to compute SK cannot be secret. In this case, assume that the ME 306 of a non-subscribed user could also compute SK from this information. Hence, the value of SK must be computed in the SUPU 316, using a secret key shared by the CS and SUMU 314. The CS and SUMU 314 share the value of RK, however each user has a unique value of RK. There is insufficient time for the CS to encrypt SK with every value of RK and transmit these encrypted values to each subscribed user. Some other technique is required.

[1066] The following paragraphs discuss the subscription process in more detail. To ensure the efficient distribution of the security information SK, the CS periodically distributes a common Broadcast Access Key (BAK) to each subscriber UIM 308. For each subscriber the CS encrypts BAK using the corresponding RK to obtain a value called BAKI (BAK Information). The CS sends the corresponding BAKI to MS 300 of the subscribed user. For example, BAK may be transmitted as an IP packet encrypted using the RK corresponding to each MS. In the exemplary embodiment, the BAKI is an IPSec packet. In the exemplary embodiment, BAKI is an IPSec packet containing BAK that is encrypted using RK as the key. Since RK is a per-user key, the CS must send the BAK to each subscriber individually; thus, the BAK is not sent over the broadcast channel. The MS 300 passes the BAKI to the UIM 308. The SUPU 316 computes BAK using the value of RK stored in SUMU 314 and the value of BAKI. The value of BAK is then stored in the SUMU. In the exemplary embodiment, the BAKI contains a Security Parameter Index (SPI) value instructing the MS 300 to pass BAKI to the UIM 308, and instructing the UIM 308 to use the RK for decrypting the BAKI.

[1067] The period for updating the BAK is desired to be sufficient to allow the CS to send the BAK to each subscriber individually, without incurring significant overhead. Since the ME 306 is not trusted to keep secrets for a long time, the UIM 308 does not provide the BAK to the ME 306. The BAK serves as the security association between the CS and the group of subscribers of HSBS service.

[1068] The following paragraph discusses how the SK is updated following a successful subscription process. Within each period for updating the BAK, a short-term interval is provided during which SK is distributed on a broadcast channel. The CS uses a cryptographic function to determine two values SK and SKI (SK Information) such that SK can be determined from BAK and SKI. For example, SKI may be the encryption of SK using BAK as the key. In the exemplary embodiment, SKI is an IPSec packet containing SK that is encrypted using BAK as the key. Alternatively, SK may be the result of applying a cryptographic hash function to the concatenation of the blocks SKI and BAK.

[1069] Some portion of SKI may be predictable. For example, a portion of SKI may be derived from the system time during which this SKI is valid. This

portion, denoted SKI_A, need not be transmitted to the MS 300 as part of the broadcast service. The remainder of SKI, SKI_B may be unpredictable. The SKI_B need not be transmitted to the MS 300 as part of the broadcast service. The MS 300 reconstructs SKI from SKI_A and SKI_B and provides SKI to UIM 308. The SKI may be reconstructed within the UIM 308. The value of SKI must change for each new SK. Thus, either SKI_A and/or SKI_B must change when computing a new SK. The CS sends SKI_B to BS for broadcast transmission. The BS broadcasts SKI_B, which is detected by the antenna 302 and passed to the receive circuitry 304. Receive circuitry 304 provides SKI_B to the MS 300, wherein the MS 300 reconstructs SKI. The MS 300 provides SKI to UIM 308, wherein the UIM 308 obtains the SK using the BAK stored in SUMU 314. The SK is then provided by UIM 308 to ME 306. The ME 306 stores the SK in memory storage unit, MEM 310. The ME 306 uses the SK to decrypt broadcast transmissions received from the CS.

[1070] In the exemplary embodiment, the SKI also contains a Security Parameter Index (SPI) value instructing the MS 300 to pass SKI to the UIM 308, and instructing the UIM 308 to use the BAK for decrypting the SKI. After decryption, the UIM 308 passes the SK to the ME 306, wherein ME 306 uses the SK to decrypt broadcast content.

[1071] The CS and BS agree on some criteria for when SKI_B is to be transmitted. The CS may desire to reduce the intrinsic monetary value in each SK by changing SK frequently. In this situation, the desire to change SKI_B data is balanced against optimizing available bandwidth. The SKI_B may be transmitted on a channel other than the broadcast channel. When a user "tunes" to the broadcast channel, the receive circuitry 304 obtains information for locating the broadcast channel from a "control channel." It may be desirable to allow quick access when a user "tunes" to the broadcast channel. This requires the ME 306 to obtain SKI within a short amount of time. The ME 306 will already know SKI_A, however, the BS must provide SKI_B to ME 300 within this short amount of time. For example, the BS may frequently transmit SKI_B on the control channel, (along with the information for locating the broadcast channel), or frequently transmit SKI_B on the broadcast channel. The more often that the BS "refreshes" the value of SKI_B, the faster the MS 300 can access the broadcast message. The desire to refresh SKI_B data is balanced

against optimizing available bandwidth, as transmitting SKI_B data too frequently may use an unacceptable amount of bandwidth in the control channel or broadcast channel.

[1072] This paragraph discusses the encryption and transmission of the broadcast content. The CS encrypts the broadcast content using the current SK. The exemplary embodiment employs an encryption algorithm such as the Advanced Encryption Standard (AES)h Cipher Algorithm. In the exemplary embodiment, the encrypted content is then transported by an IPsec packet according to the Encapsulating Security Payload (ESP) transport mode. The IPsec packet also contains an SPI value that instructs the ME 306 to use the current SK to decrypt received broadcast content. The encrypted content is sent via the broadcast channel.

[1073] Receive circuitry 304 provides the RKI and BAKI directly to the UIM 308. Further, receive circuitry 304 provides the SKI_B to an appropriate part of the MS 300 where it is combined with SKI_A to obtain SKI. The SKI is provided to the UIM 308 by the relevant part of the MS 300. The UIM 308 computes RK from the RKI and A-key, decrypts the BAKI using the RK to obtain BAK, and computes the SK using the SKI and BAK, to generate an SK for use by the ME 306. The ME 306 decrypts the broadcast content using the SK. The UIM 308 of the exemplary embodiment is not sufficiently powerful for decryption of broadcast content in real time, and, therefore, SK is passed to the ME 306 for decrypting the broadcast content.

[1074] FIG. 5 illustrates the transmission and processing of keys RK, BAK and SK according to the exemplary embodiment. As illustrated, at registration the MS 300 receives the RKI and passes it to UIM 308, wherein the SUPU 316 computes RK using RKI and the A-key, and stores the RK in UIM memory storage SUMU 314. The MS 300 periodically receives the BAKI that contains BAK encrypted using the RK value specific to UIM 308. The encrypted BAKI is decrypted by SUPU 316 to recover the BAK, which is stored in UIM memory storage SUMU 314. The MS 300 further periodically receives an SKI_B that it combines with SKI_A to form SKI. The SUPU 316 computes SK from SKI and BAK. The SK is provided to ME 306 for decrypting broadcast content.

[1075] In the exemplary embodiment the CS keys are not necessarily encrypted and transmitted to the MSs; the CS may use an alternative method.

The key information generated by the CS for transmission to each MS provides sufficient information for the MS to calculate the key. As illustrated in the system 350 of FIG. 6, the RK is generated by the CS, but RK Information (RKI) is transmitted to the MS. The CS sends information sufficient for the UIM to derive the RK, wherein a predetermined function is used to derive the RK from transmitted information from the CS. The RKI contains sufficient information for the MS to determine the original RK from the A_key and other values, such as system time, using a predetermined public function labeled d1, wherein:

[1076] RK = d1(A-key, RKI). (3)

[1077] In the exemplary embodiment, the function d1 defines a cryptographic-type function. According to one embodiment, RK is determined as:

[1078] RK = SHA'(A-key || RKI), (4)

[1079] wherein "||" denotes the concatenation of the blocks containing A-key and RKI, and SHA'(X) denotes the last 128-bits of output of the Secure Hash Algorithm SHA-1 given the input X. In an alternative embodiment, RK is determined as:

[1080] RK = AES(A-key,RKI), (5)

[1081] wherein AES(X,Y) denotes the encryption of the 128-bit block RKI using the 128-bit A-key. In a further embodiment based on the AKA protocol, RK is determined as the output of the 3GPP key generation function *f3*, wherein RKI includes the value of RAND and appropriate values of AMF and SQN as defined by the standard.

[1082] The BAK is treated in a different manner because multiple users having different values of RK must compute the same value of BAK. The CS may use any technique to determine BAK. However, the value of BAKI associated with a particular UIM 308 must be the encryption of BAK under the unique RK associated with that UIM 308. The SUPU 316 decrypts BAKI using RK stored in the SUMU 314 according to the function labeled d2, according to:

[1083] BAK = d2(BAKI, RK). (9)

[1084] In an alternate embodiment, the CS may compute BAKI by applying a decryption process to BAK using RK, and the SUPU 316 obtains BAK by applying the encryption process to BAKI using RK. This is considered equivalent to the CS encrypting BAK and the SUPU 316 decrypting BAKI.

Alternate embodiments may implement any number of key combinations in addition to or in place of those illustrated in FIG. 6.

[1085] The SK is treated in a similar manner to RK. First SKI is derived from the SKI_A and SKI_B (SKI_B is the information transmitted from CS to MS). Then a predetermined function labeled d3 is used to derive the SK from SKI and BAK (stored in the SUMU 314), according to:

[1086] SK = d3(BAK, SKI). (6)

[1087] In one embodiment, the function d3 defines a cryptographic-type function. In an exemplary embodiment, SK is computed as:

[1088] SK = SHA(BAK || SKI), (7)

[1089] while in another embodiment, SK is computed as

[1090] SK = AES(BAK, SKI). (8)

[1091] A method of providing the security for a broadcast message is illustrated in FIGs. 7A-7D. FIG. 7A illustrates a registration process 400 wherein a subscriber negotiates registration with the CS at step 402. The registration at step 404 provides the UIM a unique RK. The UIM stores the RK in a Secure Memory Unit (SUMU) at step 406. FIG. 7B illustrates subscription processing 420 between a CS and a MS. At step 422 the CS generates a BAK for a BAK time period T1. The BAK is valid throughout the BAK time period T1, wherein the BAK is periodically updated. At step 424 the CS authorizes the UIM to have access to the Broadcast Content (BC) during the BAK timer period T1. At step 426 the CS encrypts the BAK using each individual RK for each subscriber. The encrypted BAK is referred to as the BAKI. The CS then transmits the BAKI to the UIM at step 428. The UIM receives the BAKI and performs decryption using the RK at step 430. The decrypted BAKI results in the originally generated BAK. The UIM stores the BAK n a SUMU at step 432. The UIM then receives the broadcast session and is able to access the BC by applying the BAK to decryption of the encrypted broadcast (EBC).

[1092] FIG. 7C illustrates a method of updating keys for security encryption in a wireless communication system supporting broadcast service. The method 440 implements time periods as given in FIG. 7E. The BAK is updated periodically having a time period T1. A timer t1 is initiated when BAK is calculated and times out at T1. A variable is used for calculating the SK referred to as SK_RAND, which is updated periodically having a time period T2.

A timer t2 is initiated when the SK_RAND is generated and times out at T2. In one embodiment, the SK is further updated periodically having a period of T3. A timer t3 is initiated when each SK is generated and time out at time T3. The SK_RAND is generated at the CS and provided periodically to the MS. The MS and the CS use SK_RAND to generate the SK, as detailed hereinbelow.

[1093] A first timer t1 is reset when the applicable value of BAK is updated. The length of time between two BAK updates is the BAK update period. In the exemplary embodiment the BAK update period is a month, however, alternate embodiments may implement any time period desired for optimum operation of the system, or to satisfy a variety of system criteria.

[1094] Continuing with FIG. 7C, the method 440 initializes the timer t2 at step 442 to start the SK_REG time period T2. The CS generates SK_RAND and provides the value to transmit circuitry for transmission throughout the system at step 444. The timer t3 is initialized at step 446 to start the SK time period T3. The CS then encrypts the BC using the current SK at step 448. The encrypted product is the EBC, wherein the CS provides the EBC to transmit circuitry for transmission in the system. If the timer t2 has expired at decision diamond 450, processing returns to step 442. While t2 is less than T2, if the timer t3 has expired at decision diamond 452, processing returns to step 446; else processing returns to 450.

[1095] FIG. 7D illustrates the operation of the MS accessing a broadcast service. The method 460 first synchronizes the timers t2 and t3 with the values at the CS at step 462. The UIM of the MS receives the SK_RAND generated by the CS at step 464. At step 466 the UIM generates the SK using the SK_RAND, BAK, and a time measurement. The UIM passes the SK to the ME of the MS. The UIM then decrypts the received EBC using the SK to extract the original BC at step 468. When the timer t2 expires at step 470 processing returns to step 462. While the timer t2 is less than T2, if the timer t3 expires at step 472, the timer t3 is initialized at step 474 and returns to 466.

[1096] When the user subscribes to the broadcast service for a particular BAK update period, the CS sends the appropriate information BAKI (corresponding to the BAK encrypted with the RK). This typically occurs prior to the beginning of this BAK update period or when the MS first tunes to the broadcast channel during this BAK update period. This may be initiated by the

MS or CS according to a variety of criteria. Multiple BAKI may be transmitted and decrypted simultaneously.

[1097] Note that when expiration of the BAK update period is imminent, the MS may request the updated BAK from the CS if the MS has subscribed for the next BAK update period. In an alternate embodiment the first timer t1 is used by the CS, where upon expiration of the timer, i.e., satisfaction of the BAK update period, the CS transmits the BAK.

[1098] Note that it is possible for a user to receive a BAK during a BAK update period, wherein, for example, a subscriber joins the service mid-month when the BAK updates are performed monthly. Additionally, the time periods for BAK and SK updates may be synchronized, such that all subscribers are updated at a given time.

[1099] FIG. 8A illustrates the registration process in a wireless communication system 500 according to the exemplary embodiment. The CS 502 negotiates with each subscriber, i.e., MS 512, to generate a specific RK to each of the subscribers. The RK is provided to the SUMU unit within the UIM of each MS. As illustrated, the CS 502 generates RK_1 which is stored in $SUMU_1$ 510 within UIM_1 512. Similarly, the CS 502 generates RK_2 and RK_N which are stored in $SUMU_2$ 520 within UIM_2 522 and $SUMU_N$ 530 within UIM_N 532, respectively.

[1100] FIG. 8B illustrates the subscription process in the system 500. The CS 502 further includes multiple encoders 504. Each of the encoders 504 receives one of the unique RKs and the BAK value generated in the CS 502. The output of each encoder 504 is a BAKI encoded specifically for a subscriber. The BAKI is received at the UIM of each MS, such as UIM_1 512. Each UIM includes a SUPU and a SUMU, such as $SUPU_1$ 514 and $SUMU_1$ 510 of UIM_1 512. The SUPU includes a decoder, such as decoder 516 that recovers the BAK by application of the RK of the UIM. The process is repeated at each subscriber.

[1101] Key management and updates are illustrated in FIG. 8C, wherein the CS applies a function 508 to generate a value of SK_RAND, which is an interim value used by the CS and MS to calculate SK. Specifically, the function 508 applies the BAK value, the SK_RAND and a time factor. While the embodiment illustrated in FIG. 8C applies a timer to determine when to update the SK,

alternate embodiments may use alternate measures to provide periodic updates, for example occurrence of an error or other event. The CS provides the SK_RAND value to each of the subscribers, wherein a function 518 resident in each UIM applies the same function as in function 508 of the CS. The function 518 operates on the SK_RAND, BAK and a timer value to generate a SK that is stored in a memory location in the ME, such as MEM_1 542 of ME_1 540.

[1102] FIG. 8D illustrates the processing of BC after registration and subscription. The CS 502 includes an encoder 560 that encodes the BC using the current SK to generate the EBC. The EBC is then transmitted to the subscribers. Each MS includes an encoder, such as encoder 544, that extracts the BC from the EBC using the SK.

[1103] While the present invention has been described with respect to an exemplary embodiment of a wireless communication system supporting a uni-directional broadcast service, the encryption methods and key management described hereinabove is further applicable to other data processing systems, including a multi-cast type broadcast system. Still further, application of the present invention to any data processing system wherein multiple subscribers access a single transmission of secure information through an insecure channel.

[1104] Those of skill in the art would understand that information and signals may be represented using any of a variety of different technologies and techniques. For example, data, instructions, commands, information, signals, bits, symbols, and chips that may be referenced throughout the above description may be represented by voltages, currents, electromagnetic waves, magnetic fields or particles, optical fields or particles, or any combination thereof.

[1105] Those of skill would further appreciate that the various illustrative logical blocks, modules, circuits, and algorithm steps described in connection with the embodiments disclosed herein may be implemented as electronic hardware, computer software, or combinations of both. To clearly illustrate this interchangeability of hardware and software, various illustrative components, blocks, modules, circuits, and steps have been described above generally in terms of their functionality. Whether such functionality is implemented as

hardware or software depends upon the particular application and design constraints imposed on the overall system. Skilled artisans may implement the described functionality in varying ways for each particular application, but such implementation decisions should not be interpreted as causing a departure from the scope of the present invention.

[1106] The various illustrative logical blocks, modules, and circuits described in connection with the embodiments disclosed herein may be implemented or performed with a general purpose processor, a digital signal processor (DSP), an application specific integrated circuit (ASIC), a field programmable gate array (FPGA) or other programmable logic device, discrete gate or transistor logic, discrete hardware components, or any combination thereof designed to perform the functions described herein. A general purpose processor may be a microprocessor, but in the alternative, the processor may be any conventional processor, controller, microcontroller, or state machine. A processor may also be implemented as a combination of computing devices, e.g., a combination of a DSP and a microprocessor, a plurality of microprocessors, one or more microprocessors in conjunction with a DSP core, or any other such configuration.

[1107] The steps of a method or algorithm described in connection with the embodiments disclosed herein may be embodied directly in hardware, in a software module executed by a processor, or in a combination of the two. A software module may reside in RAM memory, flash memory, ROM memory, EPROM memory, EEPROM memory, registers, hard disk, a removable disk, a CD-ROM, or any other form of storage medium known in the art. An exemplary storage medium is coupled to the processor such the processor can read information from, and write information to, the storage medium. In the alternative, the storage medium may be integral to the processor. The processor and the storage medium may reside in an ASIC. The ASIC may reside in a user terminal. In the alternative, the processor and the storage medium may reside as discrete components in a user terminal.

[1108] The previous description of the disclosed embodiments is provided to enable any person skilled in the art to make or use the present invention. Various modifications to these embodiments will be readily apparent to those skilled in the art, and the generic principles defined herein may be applied to

other embodiments without departing from the spirit or scope of the invention. Thus, the present invention is not intended to be limited to the embodiments shown herein but is to be accorded the widest scope consistent with the principles and novel features disclosed herein.

[1109] WHAT IS CLAIMED IS:

CLAIMS

1. A method for secure transmissions, the method comprising:
determining a registration key specific to a participant in a transmission;
determining a first key;
encrypting the first key with the registration key;
determining a second key;
encrypting the second key with the first key; and
updating the first and second keys.

2. The method as in claim 1, wherein updating further comprises:
updating the first key according to a first time period; and
updating the second key according to a second time period, wherein the second time period is less than the first time period.

3. The method as in claim 2, wherein updating further comprises:
encrypting an updated first key with the registration key ; and
encrypting an updated second key with the updated first key.

4. The method as in claim 2, further comprising:
encrypting a broadcast stream of information using the second key; and
transmitting the encrypted broadcast stream of information.

5. The method as in claim 4, wherein the broadcast stream of information comprises video information.

6. The method as in claim 4, wherein the broadcast stream of information comprises Internet Protocol packets.

7. The method as in claim 3, further comprising:
calculating a registration key information message; and
transmitting the registration key information message.

8. The method as in claim 7, further comprising:
calculating a first key information message corresponding to the updated and encrypted first key; and
transmitting the first key information message.

9. The method as in claim 8, further comprising:
calculating a second key information message corresponding to the updated and encrypted second key; and
transmitting the second key information message.

10. The method as in claim 1, further comprising:
transmitting the encrypted first key; and
transmitting the encrypted second key.

11. A method for secure reception of a transmission, the method comprising:
receiving a registration key specific to a participant in a transmission;
receiving a first key;
decrypting the first key with the registration key;
receiving a second key;
decrypting the second key with the first key;
receiving a broadcast stream of information; and
decrypting the broadcast stream of information using the second key.

12. The method as in claim 11, further comprising:
storing the first key in a secure memory storage unit; and
storing the second key in a memory storage unit.

13. The method as in claim 11, further comprising:
recovering the first key from a first key information message; and
recovering the second key from a second key information message.

14. The method as in claim 11, further comprising:
updating the first key according to a first time period; and
updating the second key according to a second time period.

15. In a wireless communication system supporting a broadcast service option, an infrastructure element comprising:
a receive circuitry;
a user identification unit, operative to recover a short-time key for decrypting a broadcast message, comprising:
processing unit operative to decrypt key information;
memory storage unit for storing a registration key; and
a mobile equipment unit adapted to apply the short-time key for decrypting the broadcast message.

16. The infrastructure element as in claim 15, wherein the short-time key is processed by the user identification unit and passed to the mobile equipment unit.

17. The infrastructure element as in claim 15, wherein the memory storage unit is a secure memory storage unit.

18. The infrastructure element as in claim 15, wherein the memory storage unit stores a broadcast access key, and wherein the processing unit decrypts the short-time key using the broadcast access key.

19. The infrastructure element as in claim 18, wherein the short-time key is updated at a first frequency.

20. The infrastructure element as in claim 19, wherein the broadcast access key is updated at a second frequency less than the first frequency.

21. The infrastructure element as in claim 15, wherein the broadcast service option is a video service.

22. A wireless communication system, comprising:
means for determining a registration key specific to a participant in a transmission;

means for determining a first key;

means for encrypting the first key with the registration key;

means for determining a second key;

means for encrypting the second key with the first key; and

means for updating the first and second keys.

23. An infrastructure element, comprising:

means for receiving a registration key specific to a participant in a transmission;

means for receiving a first key;

means for decrypting the first key with the registration key;

means for receiving a second key;

means for decrypting the second key with the first key;

means for receiving a broadcast stream of information; and

means for decrypting the broadcast stream of information using the second key.

24. A digital signal storage device, comprising:

first set of instructions for receiving a registration key specific to a participant in a transmission;

second set of instructions for receiving a first key;

third set of instructions for decrypting the first key with the registration key;

fourth set of instructions for receiving a second key;

fifth set of instructions for decrypting the second key with the first key;

sixth set of instructions for receiving a broadcast stream of information; and

seventh set of instructions for decrypting the broadcast stream of information using the second key.

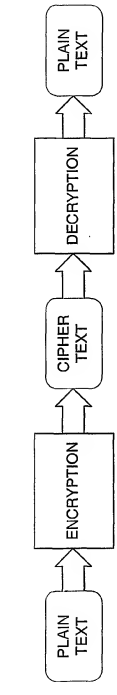


FIG. 1A

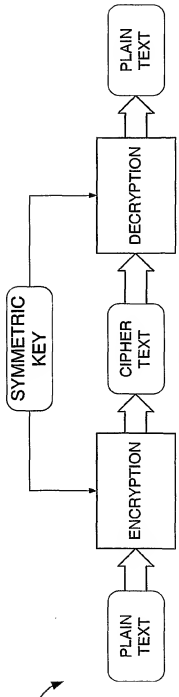


FIG. 1B

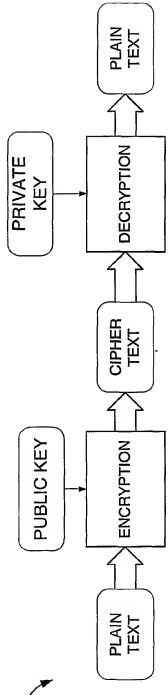


FIG. 1C

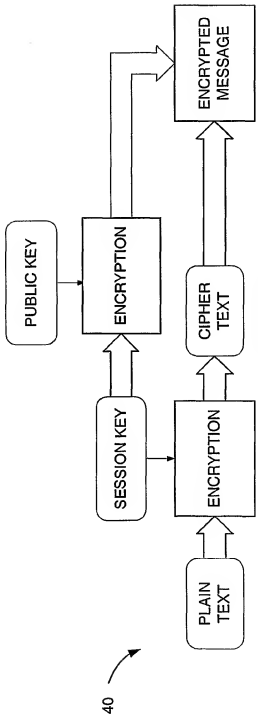

ENCRYPTED MESSAGE
PUBLIC KEY
ENCRYPTION
CIPHER TEXT
SESSION KEY
ENCRYPTION
PLAIN TEXT
40

FIG. 1D

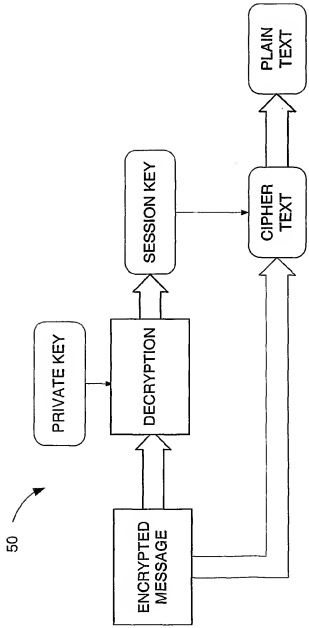

50
ENCRYPTED MESSAGE
PRIVATE KEY
DECRYPTION
SESSION KEY
CIPHER TEXT
PLAIN TEXT

FIG. 1E

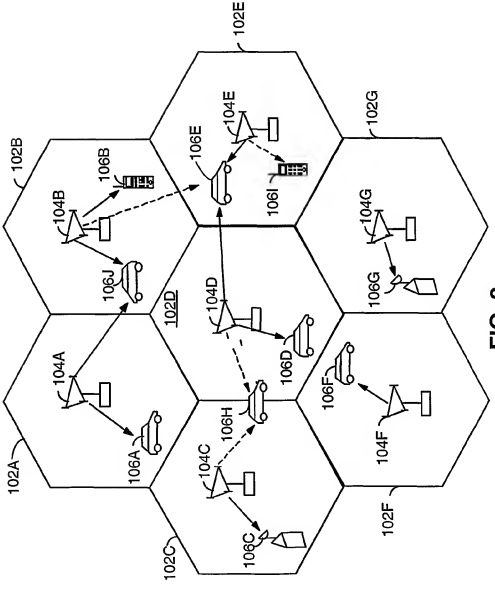

100
102A
102B
102C
102D
102E
102F
102G
104A
104B
104C
104D
104E
104F
104G
106A
106B
106C
106D
106E
106F
106G
106H
106I
106J

FIG. 2

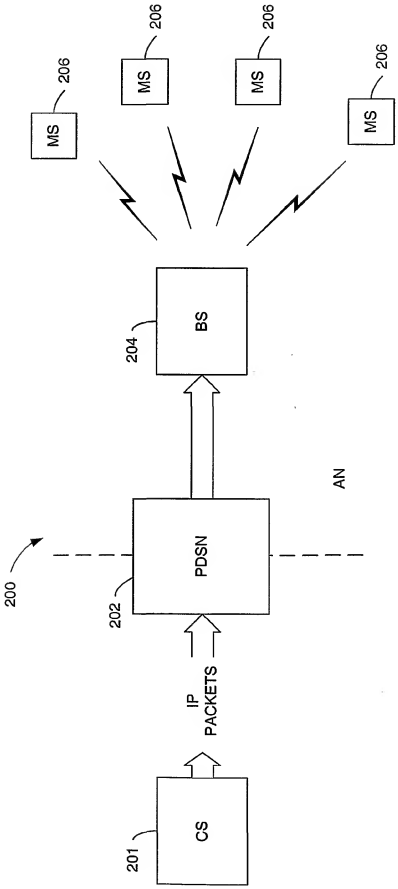

MS
206
MS
206
MS
206
MS
206
BS
204
AN
PDSN
202
200
IP
PACKETS
CS
201

FIG. 3

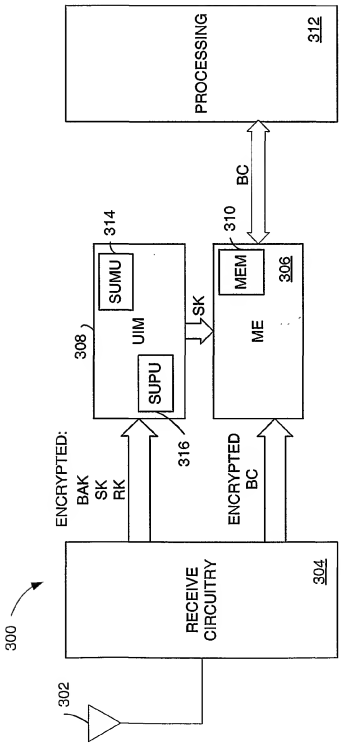

PROCESSING
312
BC
310
314
SUMU
MEM
306
SK
308
UIM
ME
SUPU
316
ENCRYPTED:
BAK
SK
RK
ENCRYPTED
BC
RECEIVE
CIRCUITRY
304
300
302

FIG. 4

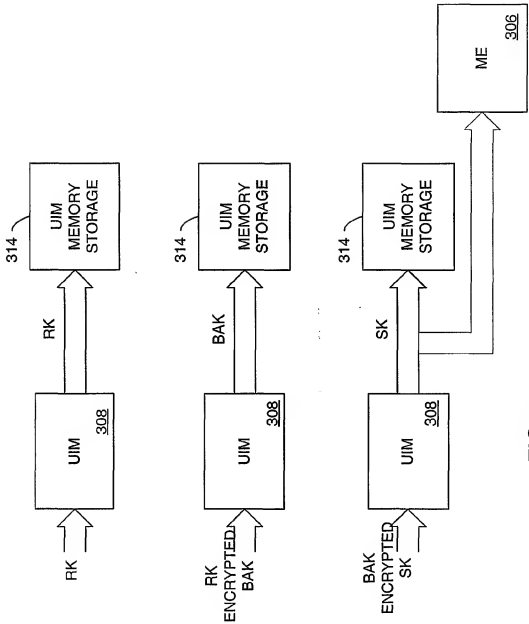

314
UIM MEMORY STORAGE
RK
UIM 308
RK
314
UIM MEMORY STORAGE
BAK
UIM 308
RK ENCRYPTED BAK
314
UIM MEMORY STORAGE
SK
UIM 308
BAK ENCRYPTED SK
ME 306

FIG. 5

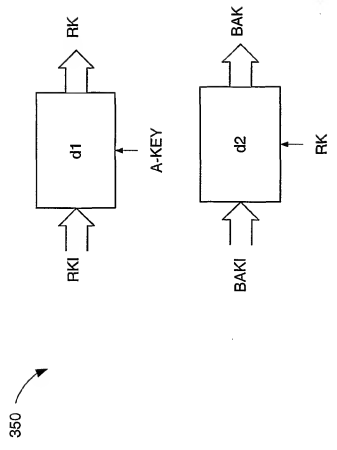


FIG. 6

400
START
402
UIM AND CS NEGOTIATE REGISTRATION
404
UIM AND CS AGREE ON RK
406
UIM STORES RK IN SUMU
END

FIG. 7A

420
START
422
CS GENERATES BAK FOR BAK PERIOD T1
424
CS AUTHORIZES UIM ACCESS TO BC FOR BAK PERIOD T1
426
CS ENCRYPTS BAK WITH RK TO FORM BAKI
428
CS TRANSMITS BAKI TO UIM
430
UIM DECRYPTS BAKI WITH RK TO EXTRACT BAK
432
UIM STORES BAK IN SUMU
END

FIG. 7B

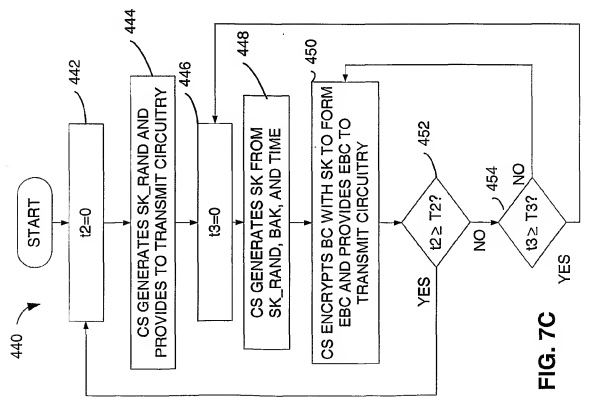

440
START
t2=0
442
CS GENERATES SK_RAND AND PROVIDES TO TRANSMIT CIRCUITRY
444
t3=0
446
CS GENERATES SK FROM SK_RAND, BAK, AND TIME
448
CS ENCRYPTS BC WITH SK TO FORM EBC AND PROVIDES EBC TO TRANSMIT CIRCUITRY
450
t2 ≥ T2?
452
YES
NO
454
t3 ≥ T3?
NO
YES

FIG. 7C

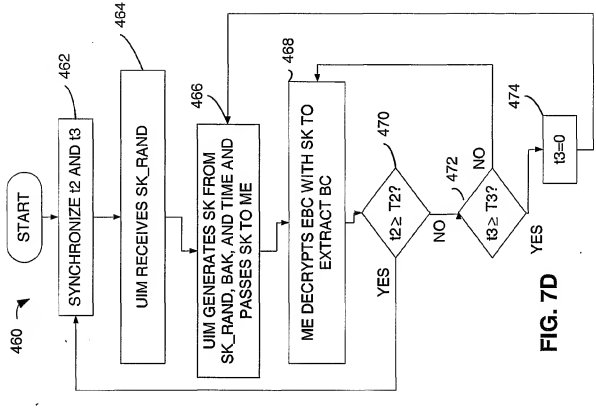

460
START
SYNCHRONIZE t2 AND t3
462
UIM RECEIVES SK_RAND
464
UIM GENERATES SK FROM SK_RAND, BAK, AND TIME AND PASSES SK TO ME
466
ME DECRYPTS EBC WITH SK TO EXTRACT BC
468
t2 ≥ T2?
470
YES
NO
472
t3 ≥ T3?
NO
YES
474
t3=0

FIG. 7D

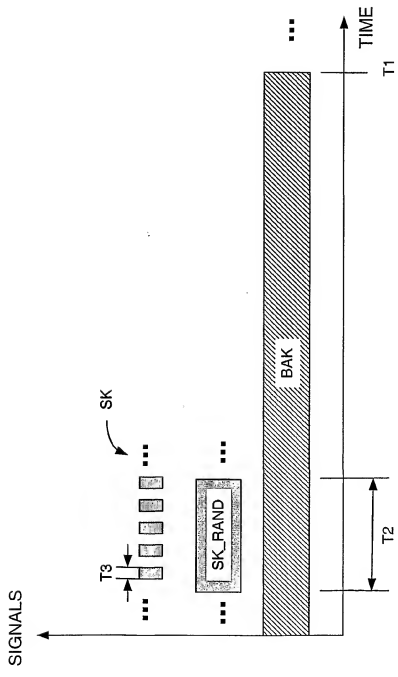


FIG. 7E

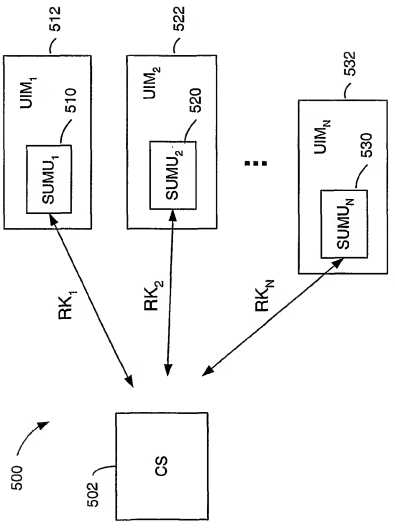

500
CS
502
RK1
RK2
RKN
UIM1
512
SUMU1
510
UIM2
522
SUMU2
520
UIMN
532
SUMUN
530

FIG. 8A

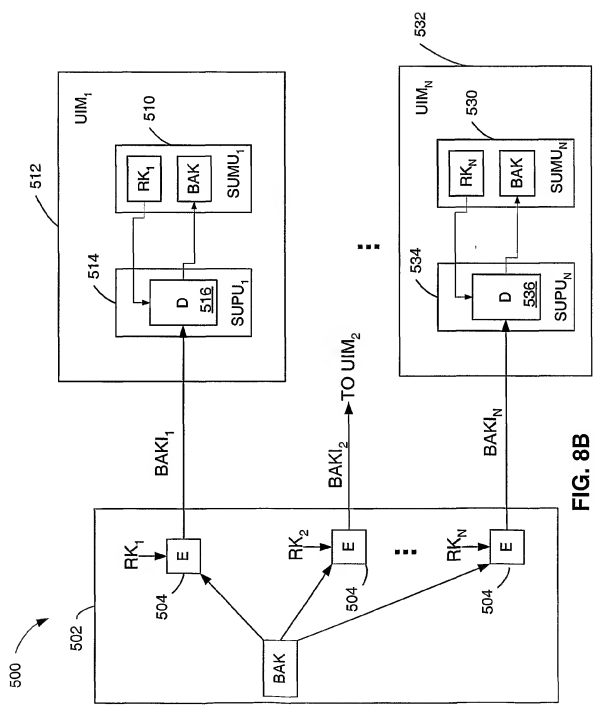

500
502
BAK
RK1
E
504
RK2
E
504
RKN
E
504
BAKI1
BAKI2
TO UIM2
BAKIN
512
UIM1
510
RK1
BAK
SUMU1
514
D
516
SUPU1
532
UIMN
530
RKN
BAK
SUMUN
534
D
536
SUPUN

FIG. 8B

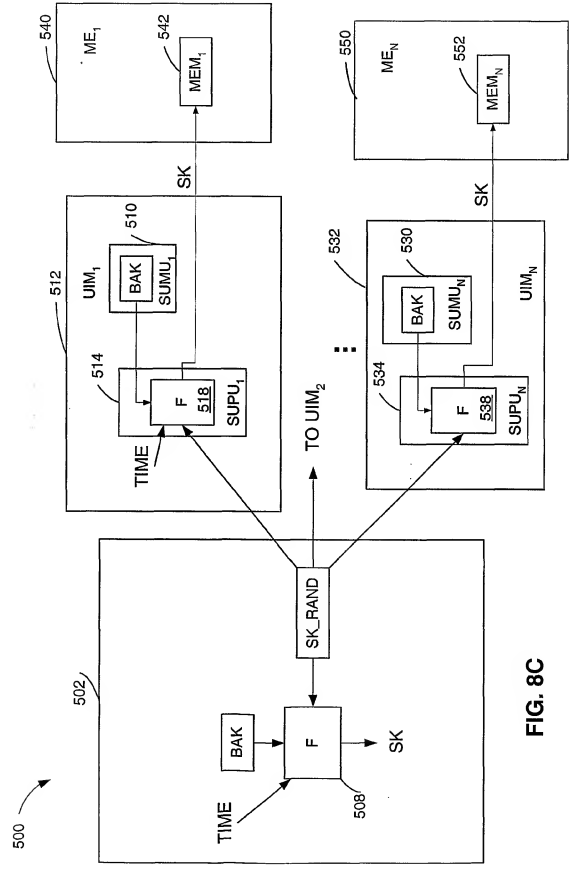

500
502
TIME
BAK
F
SK
508
SK_RAND
TO UIM2
512
UIM1
514
TIME
F
518
SUPU1
BAK
510
SUMU1
SK
540
ME1
542
MEM1
532
UIMN
534
F
538
SUPUN
BAK
530
SUMUN
SK
550
MEN
552
MEMN

FIG. 8C

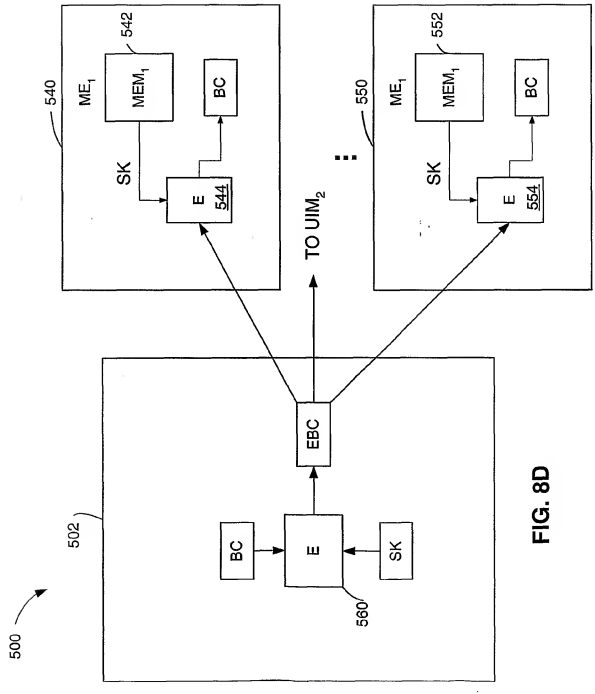

500
502
BC
E
SK
560
EBC
TO UIM2
540
ME1
MEM1
542
SK
E
544
BC
550
ME1
MEM1
552
SK
E
554
BC

FIG. 8D

INTERNATIONAL SEARCH REPORT

PCT/US 02/09835

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H04L9/08 H04Q7/38

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H04L H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, INSPEC, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	MENEZES, OORSCHOT, VANSTONE: "Handbook of Applied Cryptography" CRC PRESS SERIES ON DISCRETE MATHEMATICES AND ITS APPLICATIONS, BOCA RATON, FL, CRC PRESS, US, 1997, pages 551-553,577-581, XP002202082 ISBN: 0-8493-8523-7 page 551 -page 553 page 577 -page 581 ---	1-24
A	BERKOVITS S : "How to Broadcast a Secret" ADVANCES IN CRYPTOLOGY - EUROCRYPT '91 CONFERENCE. SPRINGER-VERLAG, 11 April 1991 (1991-04-11), pages 535-541, XP002202083 Brighton, UK, ISBN: 3-540-54620-0 page 535 -page 536 ---	1-24
	-/--	

[X] Further documents are listed in the continuation of box C.

[ ] Patent family members are listed in annex.

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
13 June 2002	08/07/2002

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Carnerero Álvaro, F

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	MARCHENT B G ET AL: "Intelligent control of mobile multimedia systems" VEHICULAR TECHNOLOGY CONFERENCE, 1998. VTC 98. 48TH IEEE OTTAWA, ONT., CANADA 18-21 MAY 1998, NEW YORK, NY, USA,IEEE, US, 18 May 1998 (1998-05-18), pages 2047-2051, XP010288261 ISBN: 0-7803-4320-4 the whole document	5,6,21